BASIC SCIENCE SERIES

ELECTRICITY

REVISED EDITION

BASIC SCIENCE SERIES — BOOK 3

REVISED EDITION

ELECTRICITY

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BASIC SCIENCE SERIES

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PREFACE

In the present technological era it is important that all children should be given a basic training in scientific knowledge. The Basic Science Series is written with this aim in mind.

The series includes 16 scientific topics each of which is a complete information book. In its entirety the scheme covers the syllabus generally adopted by upper primary classes and lower secondary forms.

The text is supported by attractive illustrations and is written in a style acceptable to a wide range of pupils.

A strong feature of each of the books is the inclusion of many simple experiments under the section "Things to Do". This encourages the pupil to keep his own project book and ultimately assists his understanding of Science.

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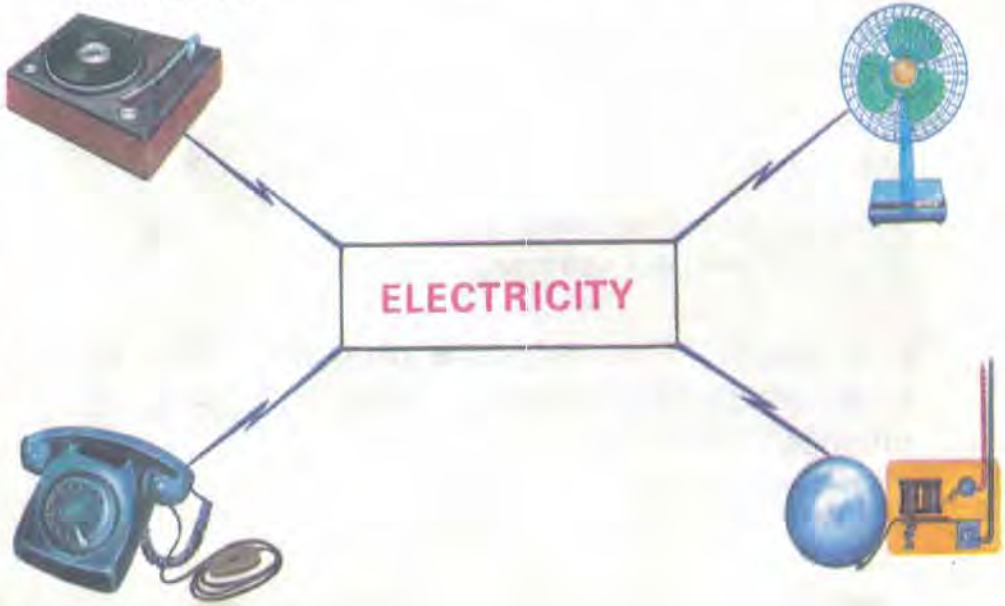
INTRODUCTION

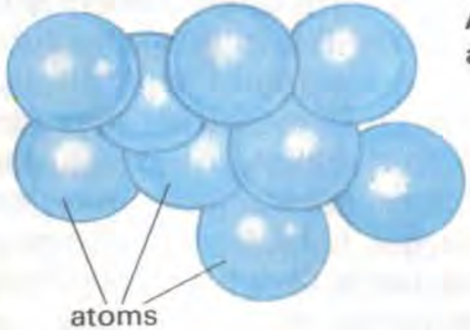
If you look up at the ceiling in your house or classroom, you will find bulbs in a lamp shade or fluorescent tubes. What are they used for? They are used to light up the room. Whenever the classroom is dark, your teacher switches on the light and the room is bright again. Have you ever wondered what causes the bulb or the tube to light up? They need electricity to light up. Electricity passes through the wires that are attached to them and this makes the bulbs and tubes glow. When they glow, they give off light. That is how we get light from electricity. Can you think of other ways in which electricity is used in your classroom, in your home or elsewhere?



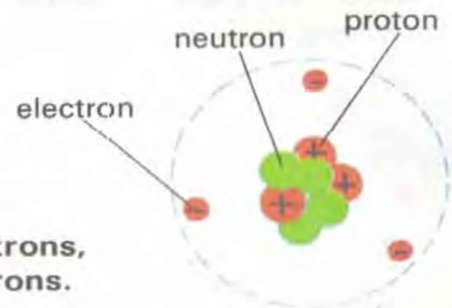
WHAT IS ELECTRICITY?

All things are made up of very tiny particles called **atoms**. Metals, wood, glass, water and gases are made of atoms.

We cannot see atoms because they are very, very small. However, scientists have found out that even atoms are made up of smaller particles. One type of particle is known as the **electron**. Another type of particle is known as the **proton**. Yet another type is known as the **neutron**.

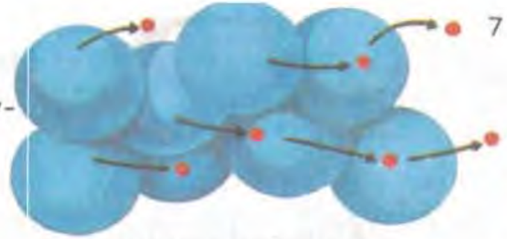


All things are made of atoms.



An atom has electrons, protons and neutrons.

Electrons have **negative charges**. Protons have **positive charges**. Neutrons have no charges.



Electricity is the flowing of electrons.

When charges move, we get an **electric current**. An electric current consists of a movement of negative charges.

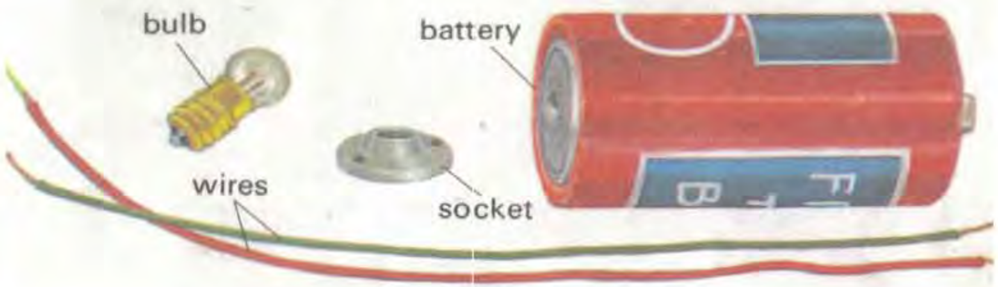
The charges that flow through the electric wire are electrons. The flow of electrons gives us electricity.

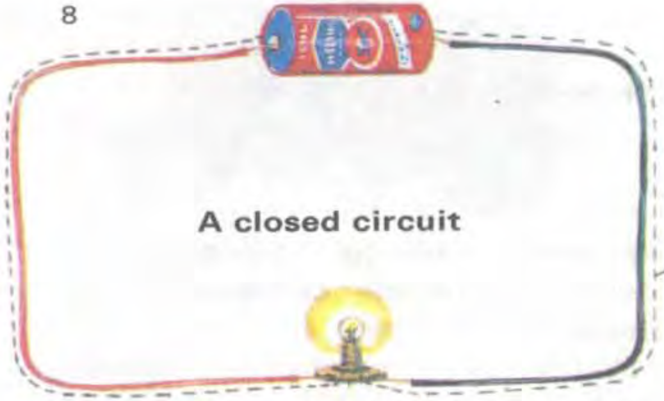
HOW ELECTRICITY TRAVELS

Electricity travels along a path. If the path is blocked, then electricity cannot keep flowing. The whole path along which electricity travels is known as a **circuit**. Let us see how electricity travels.

Things to Do

You will need the materials shown below. We are going to light the bulb. Connect your materials as shown in the picture on the next page. Use adhesive tape to stick the free end of each wire to the battery.



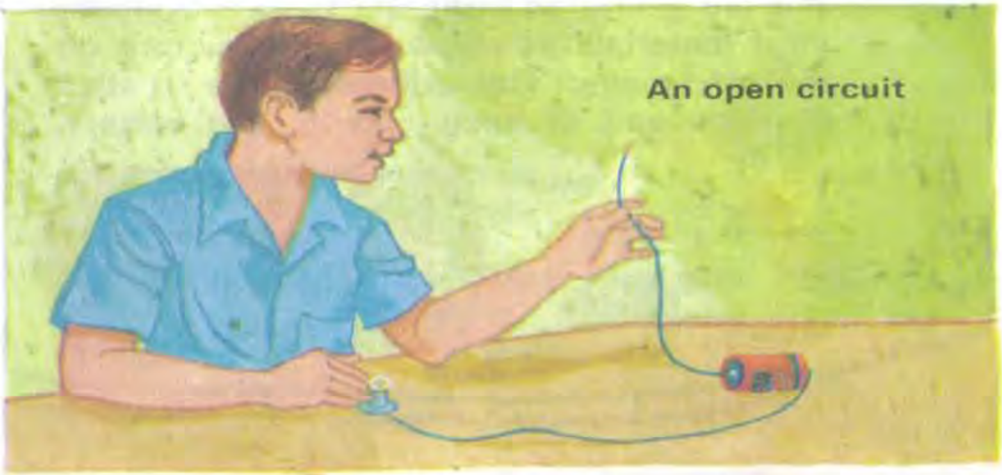


A closed circuit

What happens when you have finished your connections? Does the bulb light up?

With your finger trace the path of the electricity from one end of the battery to the other. Where does the path end? Is the path broken? An unbroken path travelled by electricity is known as a **closed circuit**.

Disconnect one of the wires. Again trace the path of the electricity.



An open circuit

Is the path of electricity broken? Does the bulb light up? Is there electricity in the circuit?

A broken path is known as an **open circuit**. Electricity will not flow in an open circuit.

CONDUCTORS AND INSULATORS

Some materials allow electricity to flow through them easily. Some materials do not. The materials that allow electricity to flow through them easily are known as **conductors**. The materials through which it is difficult for electricity to flow are known as **insulators** or **non-conductors**.

Let us test and see which are the materials that are conductors and which are the materials that are insulators.

Things to Do

Set up the circuit as shown in the picture.

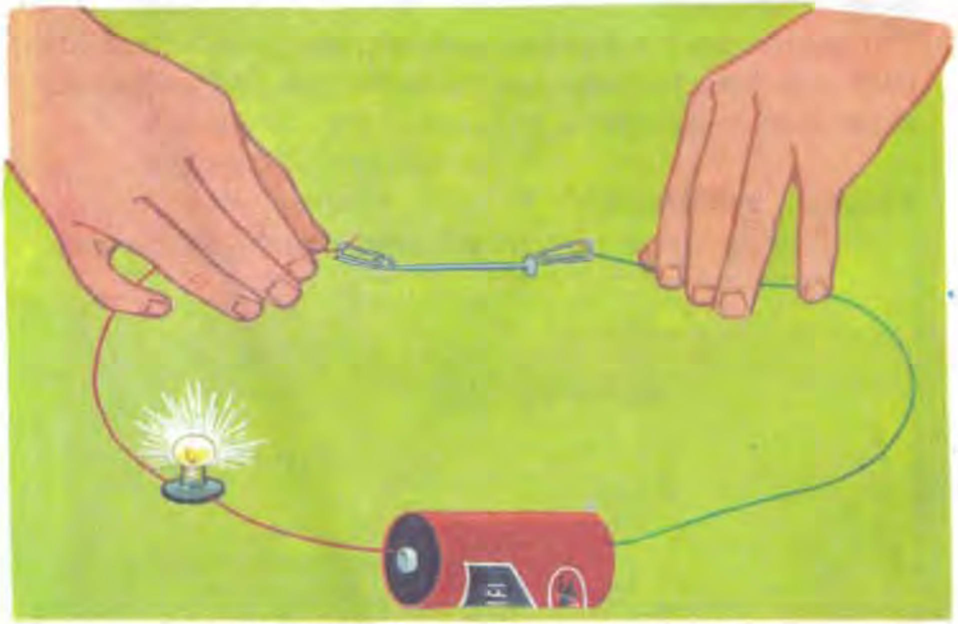
A testing circuit

Connect a paper clip to each of the free ends of the wire. Touch the two paper clips together. The bulb lights up. This shows that electricity is flowing through the circuit.

Separate the two clips. The light goes off. This means that the circuit is broken.

This kind of circuit which is used to find out whether or not electricity passes through a substance, is called a **testing circuit**.

Place a nail between the clips. Make the clips touch the nail. Does the bulb light up?



Passing electricity through a nail

If it does you know that it is a closed circuit. This means that electricity is flowing through the nail. Hence the nail is a conductor. It conducts electricity.

Place a piece of chalk between the clips. Make the clips touch the chalk. Does the bulb light up?

If it does not, you know that electricity cannot flow through the chalk. Then the chalk is an insulator. It does not conduct electricity.

Repeat the experiment using a wooden ruler, a piece of glass, a metal spoon, a coin, a piece of paper, a pin, a plastic comb, a key, a pencil, a tin lid and a rubber eraser.

Separate them into conductors and insulators. What do you notice about the conductors? Are they all metals? Are all the non-metals insulators?

Conductors are useful to us. They allow electricity to flow through them. They can form a closed circuit.

Sometimes we do not want electricity to flow into certain things. We use insulators to prevent electricity from flowing to these things. We use rubber or plastic insulators to cover electric wires in order to prevent electricity from flowing into our body. Otherwise we will get an electric shock. So we can say that insulators are also very useful to us.

HOW TO TEST FOR HIDDEN CIRCUITS

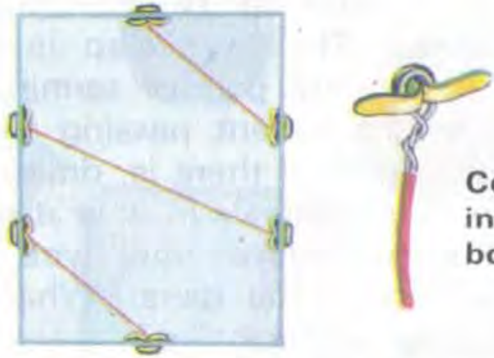
We can use the testing circuit we made earlier to find out about some other circuits which we cannot see. It is fun to find out what the results will be.

Things to Do

First of all we have to make an **octopus box**. An octopus box is one which contains a circuit inside.

Take an open chalk box. Now use a paper binder and pierce it through the wall of the box. Let the paper binder stay firmly to the wall by twisting the

How to make an octopus box



Connections made inside the octopus box

metallic strips as shown. Repeat the same procedure using a few more paper binders on different sides of the box. Connect a few pairs of the binders by wire. Close the box with a lid. What you can see now is a closed box with the heads of the paper binders stuck to the walls outside. The heads of the paper binders are called terminals.

Turn your box round another way. Draw a diagram showing the positions of the terminals. Use your testing circuit. See

Before testing your circuit, draw a diagram of this kind.

whether it is working by touching the clips together. The next step is to let the clips touch any pair of terminals. Is there an electric current passing through the two terminals? If there is, draw a line joining the two terminals in your diagram. Repeat this procedure until you have finished testing all the pairs. What does your final diagram look like?

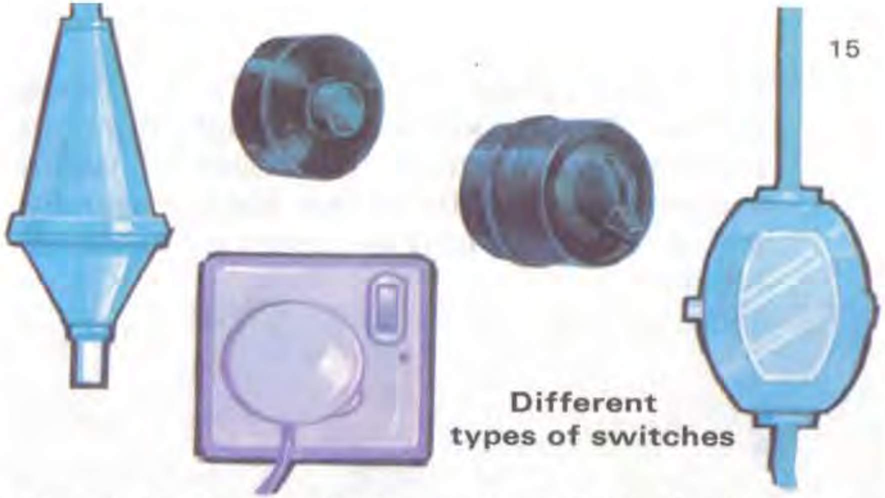
Open up the lid and see whether the circuit you have drawn is like the actual circuit in the box.

Ask your friend to make another octopus box using a different number of paper binders and a different set of connections. Exchange your box with his. Test the hidden circuit the same way as you have tested the first. Draw the circuit diagram. Check and see whether you are correct by opening up the box.

HOW TO TURN ELECTRICITY ON AND OFF

We use electricity very often. We use electricity to work our radios. We use electricity to turn fans. We use electricity in electric kettles to boil water and we use electricity to give us light.

However, we do not keep our radio on all the time. Sometimes when it is cold, we do not want the fan to keep on turning. After



Different types of switches

the water has boiled, we do not need any more electricity. We definitely do not need to have the light on when it is very bright. Therefore we must have something to turn electricity on and off whenever we need to.

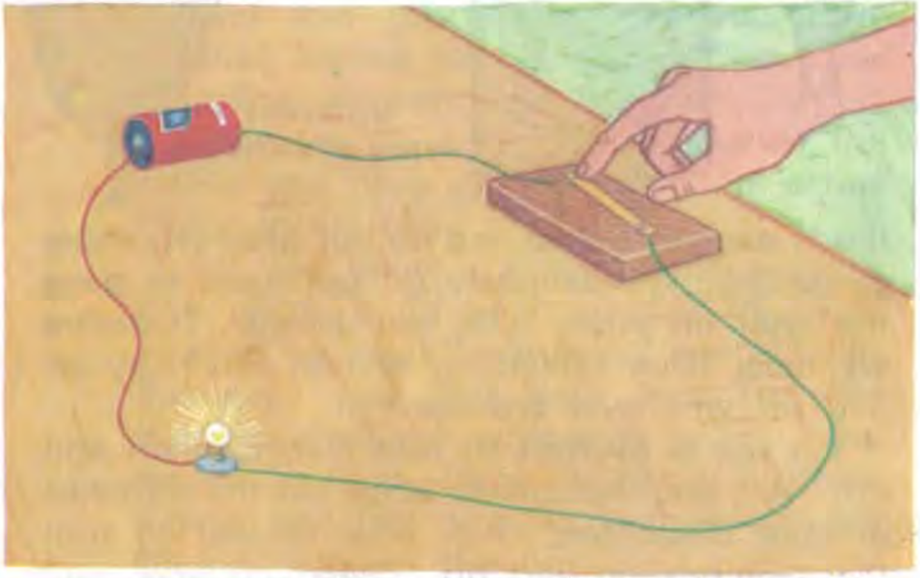
We use a **switch** to turn electricity on and off. Ask your teacher to point out the switches in your classroom. Ask your teacher to turn the switches on and off. What do you see?

Things to Do

(i) Take a metal strip and a piece of wood. Make a simple switch as shown in the picture. Which parts of the switch can conduct electricity?

A simple switch

Use your switch to connect a circuit as shown. Do you know how to light the bulb by using the switch? Try doing it. When the light is on, trace the path made by the electricity. Is it an open or a closed circuit?



Using a simple switch to close a circuit

How do you turn off the light by using the switch? With a finger, trace the path made by the electricity. Is the roundabout path broken? If this is so, what do you call this kind of circuit?

(ii) Remove the switch that you have made above. Take another strip of metal. Try to find a different way of making another switch. Show it to your teacher. Draw a picture of your switch in your note book.

A ·-	J ·---	S ···
B -···	K -·-	T -
C -·-·	L ·-··	U ··-
D -··	M --	V ···-
E ·	N -·	W ·--
F ··-·	O ---	X -··-
G --·	P ·--·	Y -·--
H ····	Q --·-	Z --··
I ··	R ·-·	

Morse Code

(iii) We can use the switch you have made to send messages. Connect the circuit. Press the switch and let go. You will see a short flash of light from the bulb. Now press the switch on longer. You will see a longer flash of light. Before you start sending a message, look at the chart above.

You will notice that each of the alphabet consists of a series of dots and dashes. This is known as the **Morse Code**. A dot stands for a short flash of light. A dash stands for a longer flash of light.

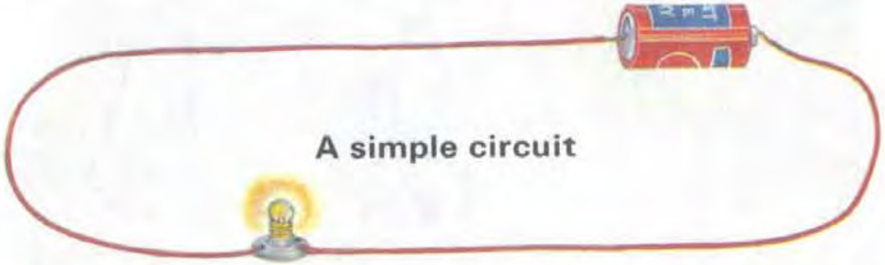
If you want to send the letter 'S', you have to make three short flashes of light. If you want to send the letter 'Q', you have to make two long flashes followed by a short flash, followed immediately by a long flash.

Ask your friend to note down the short and long flashes. Compare them to the chart. What letters have been sent? Now write down a sentence and send it by Morse Code. Ask your friend to take note of your message and tell you what the message is.

Sending messages by Morse Code

HOW TO LIGHT TWO BULBS IN A CIRCUIT

Earlier, you learned how to light a bulb by connecting a simple circuit. Can you still remember how to do it?

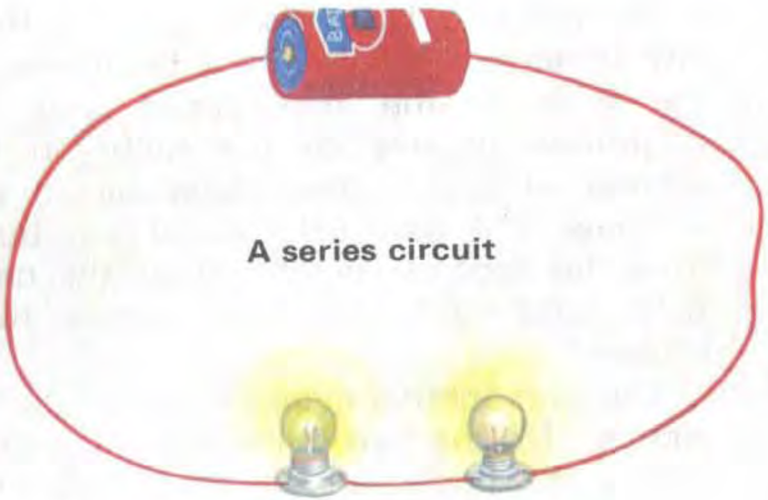


A simple circuit

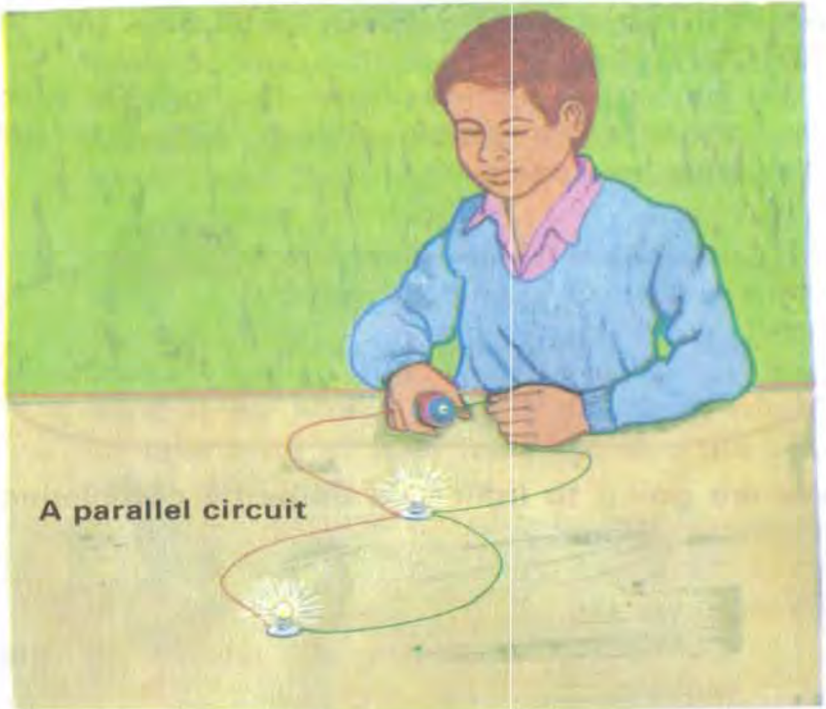
We are going to light two bulbs by completing a single circuit.

Things to Do

Connect the circuit as shown in the picture.



A series circuit



Do the two bulbs light up? Is there any difference between the brightness of the bulb in the first circuit and the brightness of one of the bulbs in the second circuit? What happens if you unscrew and take off one of the bulbs from the second circuit? Does the other bulb light up? Has the circuit been broken?

Connect another circuit as shown in the picture. Do the two bulbs light up again? Notice the brightness of each bulb. Are

they brighter than the bulbs of the previous circuit? Disconnect one of the bulbs. Does the other bulb light up? It does. Because of this behaviour, the bulbs in our homes are connected in this way.

We call the first arrangement a **series circuit** and the second a **parallel circuit**.

BATTERIES AND WAYS TO OBTAIN ELECTRICITY

There are many kinds of batteries. The batteries we are using are also known as **dry cells**. Other forms of dry cells are shown in the picture. A dry cell can give a steady current for a certain time. Then the current becomes weaker and weaker and finally no more current is produced by the battery. It is of no use to us anymore.

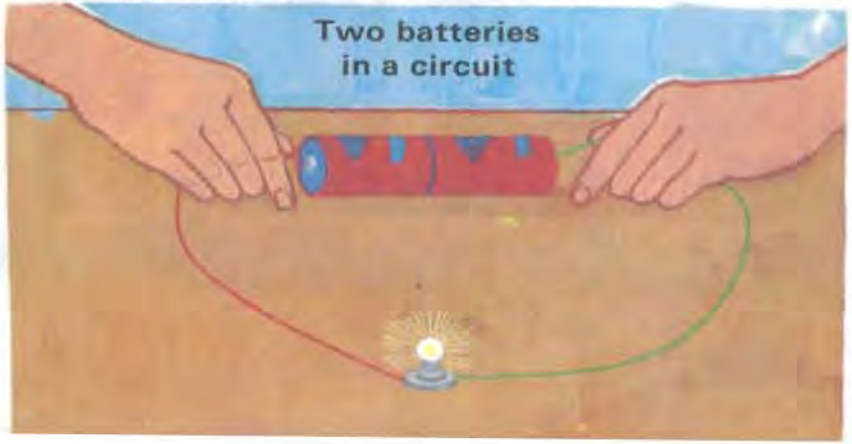
Dry cells

An accumulator

On the other hand, there is another type of cell known as the **wet cell**. Inside the cell there is liquid. That is why we call it a wet cell. We call the wet cell shown above an **accumulator**. It can give us electricity for a long time. When it becomes weak we can make it stronger by a process called **recharging**.

Things to Do

(i) We already know that we can light a bulb by using a battery. We are going to see what happens if we add another battery to the circuit. Connect the apparatus as shown below.



Two batteries in a circuit

What happens to the bulb? Notice the brightness of the bulb. Is it brighter than the bulb of the circuit with a single battery? Can you explain why?

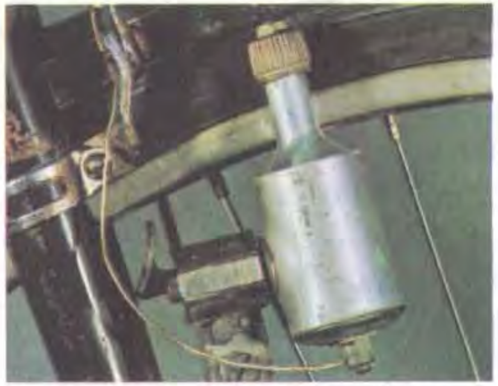
Turn over one of the batteries and join them in opposite directions. Does the bulb light up? Now do you know the correct way to connect batteries so that the bulb lights up? Try and see whether you can find another way of joining the batteries to let electricity flow round the circuit.

(ii) Take a torch which has no batteries inside it. To light a torch you need batteries. See whether you know how to put in the batteries so that the torch will light up.

(iii) A transistor radio also needs batteries to work. Open up a transistor radio. Observe how the batteries are placed inside. Take out the batteries. Do you know how to put in the batteries again so that the radio will work again? Try doing it.

From your experiments, you can see that batteries are very important in a circuit. It is the thing that drives electrons around the circuit. When electrons move around the circuit we have electricity.

If we have two batteries connected in the proper way, then the drive or push becomes



A bicycle dynamo

stronger. Therefore there is more electricity.

Can you now explain why your bulb is brighter with two batteries in the circuit than with one battery?

There are other ways of obtaining electricity besides using the dry and wet cells. One way is to make use of a **dynamo**. It is a machine that makes electricity. A bicycle dynamo can usually be found near either wheel of a bicycle. When the head of the bicycle dynamo is turned by the wheel of the bicycle, electricity is produced.

Generators

The electricity which we use for electric bulbs, fans, kettles and irons is produced by **generators**. A generator is actually a very big dynamo. It can produce a very large amount of electricity. Generators are found in a **power station**. Electricity produced in a

A large amount of electricity is produced in a power station.

power station is allowed to flow through good conductors like metallic cables. The cables run from the power station to our houses and schools. Then they run back from our houses and schools to the power station, forming a closed circuit. Sometimes we cannot see the cables. This is because in some places the cables are laid underground.

ELECTRICITY CAN GIVE US HEAT

Let us find out more about electricity. We want to see what we can learn from the following activities.

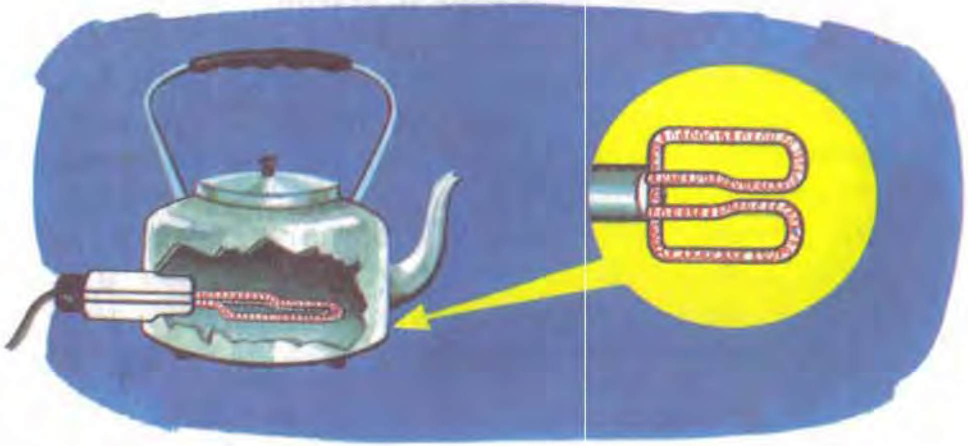
Things to Do

(i) Put your hand near a lighted electric bulb for a while. Can you feel the heat coming from the bulb?

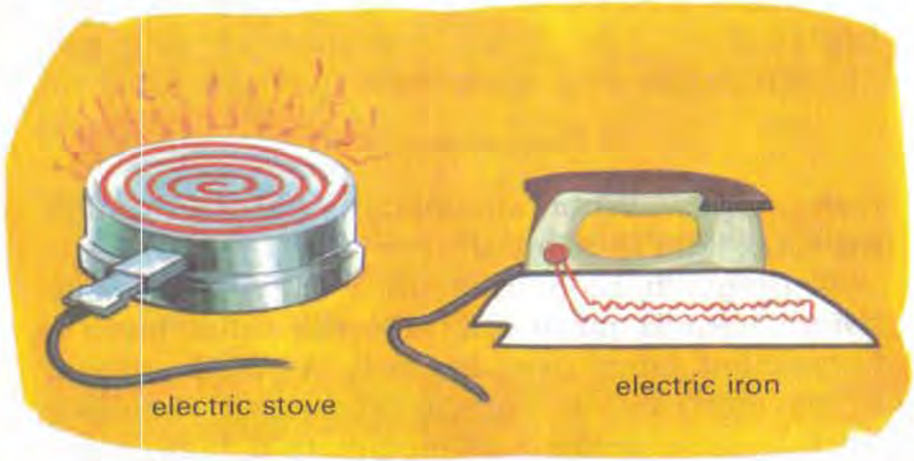
(ii) Switch a torch on for some time. Now feel the torch with your hand. Does the metal casing feel warm?

(iii) Ask your teacher to connect an electric kettle containing water to an electrical circuit. Switch it on. After a few minutes, touch the kettle. Is heat produced in the kettle? There is a long piece of coiled wire inside the kettle. Electricity passes through it and heat is produced. It is this heat that makes the water boil.

An electric kettle



Can you name a few more electrical appliances where electricity is used to produce heat?



Electricity can be changed to heat

ELECTRICITY CAN GIVE US LIGHT

Think over all the experiments you have done so far. Did you notice that every time electricity is passed through the thin wire of a bulb, light is produced? We say that some of the electricity has been changed to light. Actually the changing of electricity into heat takes place first. When electricity is passed through the thin tungsten wire inside the bulb, it makes the wire very hot. The wire becomes so hot that it glows. When it glows, it gives off light.

Electricity is also converted to light in the fluorescent lamp. This is a glass tube filled with

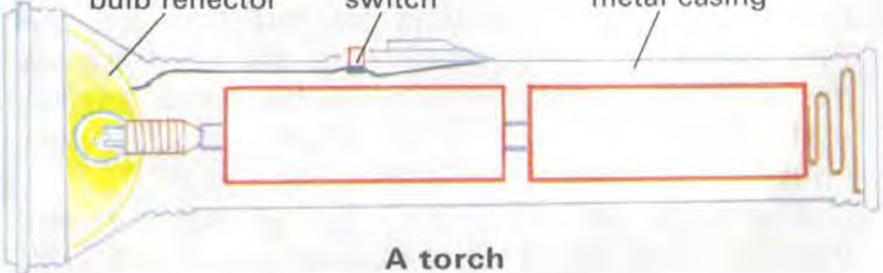
A fluorescent lamp

mercury gas. When electricity is passed through the tube, light is given off.

A tungsten bulb uses up a lot of electricity before light is produced. On the other hand a fluorescent lamp uses up only a small amount of electricity before light is produced. Therefore for the same amount of electricity a fluorescent lamp gives off more light than a tungsten bulb.

Things to Do

We have used a torch before. Take a torch and examine it carefully. What does it consist of? How is the circuit connected so that electricity can flow past the wire in the bulb to be converted partly to light?



A torch

ELECTRICITY CAN GIVE US MAGNETISM

It has already been found out that electricity can give us heat and light. We have yet to find out another interesting fact about electricity.

Things to Do

Take an iron nail. Use a piece of insulated wire and wind it round the iron nail, leaving the two ends of the wire free.

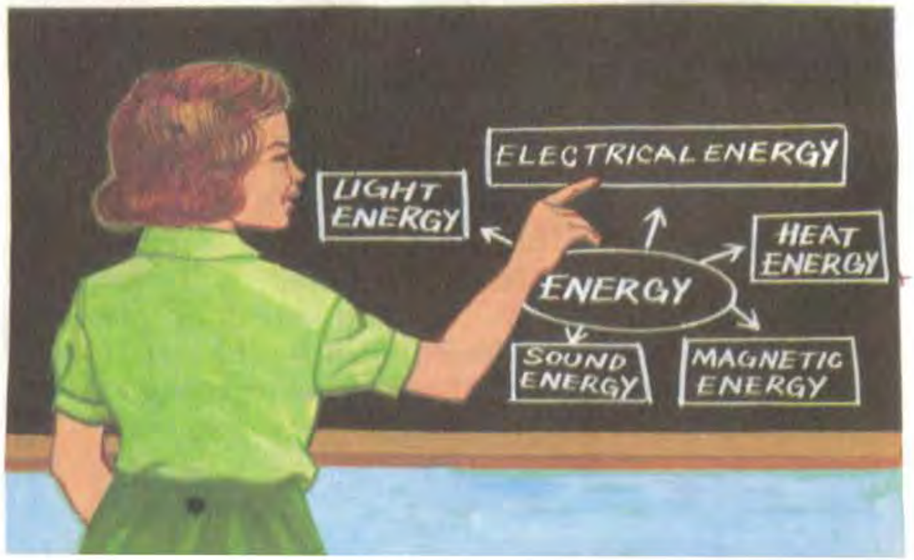
How to magnetize an iron nail

Connect the two ends to an electrical circuit. Now switch on the circuit. Put the iron nail near a pin or a clip. What happens? The pin or the clip is attracted to the iron nail. The nail is behaving like a magnet. Switch off the circuit. Does the pin or clip drop off? It does. This means that there is no magnetism in the iron nail any more.

When electricity is passed through the wire wound round the iron nail, magnetism is produced. We do not get the magnetic effect if no electricity passes through the wires. Thus we can say that electricity can produce magnetism.

ELECTRICITY IS A FORM OF ENERGY

We have come to another important point in our study of electricity. This is that electricity can be converted either to heat, light or magnetism. Electricity, heat, light and magnetism are all forms of **energy**. There are a few more forms of energy. But we know that electrical energy can be changed to light energy, heat energy or magnetic energy. Our experiments have shown us that electricity is only one of the many forms of energy.



BE CAREFUL OF ELECTRICITY

Electricity is very useful to us in many ways. We can use it to make our lives more comfortable. But it can be very DANGEROUS to us also.

The electricity which we use from the electrical circuits in our homes and schools can KILL us if we are not careful. Here are some points to remember.

1. Do not touch a bare wire from the main electrical circuit. It may be a live wire, that is, there may be electricity in it. If you touch it, the electricity will flow into your body and give you an electric shock.

2. Climbing a lamp post carrying electric wires is dangerous. A lamp post is usually made of metal and is therefore a good conductor of electricity. Some electricity may have escaped from the electric wires to the lamp post and so you could be electrocuted.

3. Do not push a needle through an electric wire. An electric wire is covered by rubber or plastic insulators. If you do so, electric current will flow through the needle to your body.
4. Do not try to repair electrical appliances. Leave it to an electrician.
5. Touching an electrical appliance with wet hands is dangerous! Water can conduct electricity.
6. Ask an electrician to tell you about electrical safety.

MEASUREMENT OF ELECTRICITY

Electric current in a wire is something like water current in a pipe.

The amount of electricity passing through the wire per second is measured in **amperes** (A). Amperes measure electric current.

The "pressure" pushing the electricity along the wire is measured in **volts** (V).

A torch battery is $1\frac{1}{2}$ volts. A car battery is 6 volts or 12 volts. Electricity in a house or school is 240 volts.

The amount of electrical energy used in homes, schools, etc. is measured by an electricity meter in **kilowatt-hours**. **Watt** is the unit of power or rate of doing work. A kilowatt-hour is the electrical energy supplied by a rate of working of 1,000 watts for 1 hour. How much electrical energy can the power station near your home produce?